Hydropower framework analysis in a few selected African and Latin American countries: A general overview

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Summary

The paper briefly reports on the hydropower sector framework in the selected target countries, namely: Bolivia, Colombia, and Ecuador (Latin America), Cameroon, and Uganda (Africa). It briefly provides the methodology of analysis and is structured of the following: a) Power sector and renewable electricity policy; b) Hydropower sector and potential; c) Small hydropower (SHP) situation; d) Hydropower research situation; e) Prospects for large and small hydropower. This paper is based on the HYPOSO project findings presented in the "Report on Framework Analysis and Research Needs in Five Target Countries" completed between 2019 and 2020 (deliverable D3.2).

Methodology

The analysis was based on the following main steps: 1) Collection of existing information of the data holders and review a wide range of available papers and reports published in open sources and grey literature. Past and ongoing studies on hydropower issues were extensively used; 2) Two comprehensive questionnaires designated for the project partners, experts, and stakeholders in the target countries. The first questionnaire consisted of Market data (Industrial and Economics), Policy data (Legislation and Concession regime, and support), Financing, Education, and Research needs. The aim of the second questionnaire " Inventory of R&D projects" was to identify past and outgoing R&D activities, complementing them by Innovation (R&I) of the hydropower sector in these countries to facilitate the European technology transfer from the laboratories to the market, enhancing the European industry position and helping it to keep its leadership in this field.

1. Bolivia

1.1 Power sector and renewable electricity policy

The major share of Bolivia's electricity is covered by the non-renewable thermal sources of natural gas combustion turbines Their installed capacity is 1,538 MW (62 %) and the energy produced in 2016 was 6,947 GWh (79.3 %). This is followed by the hydropower sector with a total installed capacity of 734.84 MW (30 %) and energy produced by 1,715 GWh (19.6 %). The share of other renewable energy sources is still insufficient. The Government has plans to develop the electricity sector by increasing the country's installed capacity, which will be supplied mainly from hydropower schemes.

The Renewable Energy Policy Brief in Bolivia was compiled by the International Renewable Energy Agency (IRENA, 2015). The framework for electricity generation in Bolivia is the 1994 electricity law (Law 1604). A new electricity law reflecting the 2009 constitutional changes is under development. A new Renewable Energy Law is also under development.

1.2 Hydropower sector and potential

Bolivia has a gross theoretical hydropower potential of 178,000 GWh/year (HP&D, 2019). The technically feasible potential has been estimated as 126,000 GWh/year, and the economically feasible potential is between 30,000 and 50,000 GWh/year. Hydropower plants generated about 2,500 GWh in 2018. Less than 2 % of the technically feasible potential has been developed so far.

A recent study based on GIS technologies identified the gross theoretical hydropower potential of 133 GW in Bolivia (Velpuri et al., 2016). Although protected areas were excluded from it, the real potential – technically or economically feasible potential remains still unknown. As of 2019, Bolivia had 16 large hydropower plants in operation with further 6 plants under construction (total capacity 659MW).

1.3 SHP situation

The definition of small hydropower in Bolivia is up to 5 MW. So far, the small hydropower potential as expressed in real figures is not known as it is the case for all hydropower nor reliable inventory of SHP plants. After the highest estimate, there are 85 smalls, mini- or micro-hydro plants in operation, with individual capacities of up to 10 MW, and the total capacity of 153 MW, which generated 629 GWh in 2016. SHP plants belong to both private and public (ENDE) companies.

Some 18 contacts of stakeholders involved in one or another way in the hydropower sector were identified in Bolivia. There are some 10 companies active in the SHP sector. Well-developed hydropower equipment manufacturing industry is lacking except small turbines produced occasionally for micro-hydro facilities (Universidad Mayor de San Andres, UMSA). Only one company is acting for the equipment suppliers. 4 companies are involved in engineering activities. Operation & maintenance services are not well developed.

Most of the SHPs in Bolivia belong to private companies. The energy tariffs for new projects are not defined yet, nor financial mechanisms exist. Regulations and investment frameworks are in the process of being implemented. Each project will have to be negotiated in order to establish the energy price through a purchase agreement according to ENDE's requirements, the interests of the investor, and AE's authorizations.

The average investment cost (€/kW) ranges between 1,640 and 2,500 for small and medium to large hydro, respectively. The average cost per kWh produced is € 0.074.

1.4 Hydropower research situation

Instituto de Hidraulica e Hidrologia (IHH) is a research unit of the Universidad Mayor de San Andres (UMSA), the university in La Paz. They are specialized in micro/small hydro technology and have been researching it for more than 30 years (Drinkwaard, 2009). Laboratorio de Hidraulica of Universidad Mayor de San Simon (UMSS), the university in Cochabamba, specializes in numerical modeling river flow and hydropower operations.

In total, some 19 R&D projects were identified conducted from 2011 to 2019. Five of them are dealing with large hydro. The majority of these projects were implemented during the last 5 years. Almost all the projects were conducted by universities. No fundamental research (also known as basic research or pure research) elements have been identified.

The survey conducted in Bolivia revealed the following research topics to be undertaken in the future, but not limited to: hydrology, climate change impact, multipurpose schemes, diagnostic studies, O&M, socio-environmental and economic.

1.5 Prospects

1.5.1. Large hydro

There is an ambitious target to generate as much as 70 to 78 % of domestic electricity from hydropower by 2025. The target of ENDE is to have 3,000 MW of hydropower capacity as soon as possible, which would allow the country soon to use about 1 GW for electricity export purposes. In the medium term, an estimated US$ 16.7 billion will be invested in new hydropower projects (HP&D, 2019, IHA, 2019). This plan is heavily reliant on two large hydropower schemes. The export to Brazil and Argentina is very attractive in terms of power price that is about seven times higher than the price established for the local market, which has been subsidized for energy production (WSHPDR, 2019)

1.5.2 Small hydro

The Government's strategic plan includes SHP projects of approximately 30 MW for grid connection and another 20 MW for isolated networks, all of them in the progress of identification. Such projects as well as other endeavours can be studied, developed, and constructed by public or private investment. The Government is also working on the structure and rules to finance small hydropower and other renewable energy technologies, such as by assigning incentives to the local government departments when the installed capacity is below 2 MW; and to the municipalities or the indigenous authorities when the project is of an installed capacity less than 1 MW.

2 Colombia

2.1 Power sector and renewable electricity policy

Colombia has a rich endowment of energy sources and the country is heavily reliant on installed hydropower (from 70 to 80 % per of annual electricity generation), which provides cost-effective electricity. It has the third-largest installed hydropower capacity in South America, at 11,771 MW.

In 2015, Colombia had a total installed electricity generation capacity of 16.4 GW, with a share of 62.1 % of large hydropower (plants with an installed capacity bigger than 100 MW), 4.2 % of medium hydropower (20 to100 MW), and 3.7 % of SHP (<20 MW). The average annual hydro generation of the hydro plants in operation was 60,620 GWh/year, which was 84.1 % of the national power production in 2018. This includes 56,193 GWh/year from large plants (78.0 %) and 4,427 GWh/year (6.1 %) from small hydro plants (UPME, 2018).

The New Renewable Energy Law (REL) was adopted in April 2014. The REL approved the International Renewable Energy Agency Statute as an attempt to promote the adoption and sustainable use of all forms of renewable energy. In 2017 the Fund for Unconventional Energies and Efficient Energy Management ('Fenoge Fund') was created.

2.2 Hydropower sector and potential

Colombia has the second-largest hydropower potential in Latin America, after Brazil (OLADE, 2013). The gross theoretical hydropower potential of Colombia is about 1,000 TWh/year, of which 200 TWh/year is technically feasible. 140 TWh/year was economically feasible according to estimates made several years ago (H&D, 2019).

According to the data from Colombia’s National Mining and Energy Planning Unit (UPME) and the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), the theoretical hydropower potential is estimated at 56 GW countrywide (UPME, 2015). This includes 8,113 MW at plants of 20 to 40 MW and 43,129 MW at plants larger than 40 MW. Of the total potential, 41.1 % is in the Magdalena Cauca hydrographic basin, 23.7 % in the Orinoco basin, 22.1 % in the Amazon basin, 6.8 % in the Caribe basin, and 6.4 % in the Pacific basin.

As of February 2019, the total installed hydropower capacity was 11,771 MW (including 22 plants of at least 50 MW capacity), which is 68 % of total installed capacity (H&D, 2019). About 55 % of the hydro capacity is privately owned. Three main utilities EPM (public), Emgesa (mixed capital), and ISAGEN (private) account for 75 % of installed hydropower capacity.

In 2015, a comprehensive atlas of Colombia's Hydropower Potential was launched (UPME, 2015). This atlas indicates 4,947 MW hydro potential for plants of up to 20 MW capacity.

2.3 SHP situation

In Colombia, the definition of SHP was adopted, which involves a plant capacity less than or equal to 20 MW and that operates at run-off-river, with no water storage (Duque et al, 2016; Arias-Gaviria et al., 2017).

There are some 35 SHP companies registered and trading energy through the stock market, with about 120 SHP stations and an installed capacity of 955 MW. Additionally, there are at least 200 smaller power plants, not registered at the stock market, and more than a thousand abandoned or dismantled SHPs. There is no comprehensive, centrally processed data for such power plants.

A comprehensive overview of the SHP sector in Colombia is given in Morales et al. (2015). It considers the current installed capacity and existing potential of hydropower resources, reveals the barriers that hinder the development of SHP in the country, presents main perspectives for the future.

In Colombia and the neighbouring countries, SHP lobbying, and other activities are implemented by CELAPEH - a non-profit organisation founded by six Colombian and international institutions (CELAPEH, 2020).

Nearly 60 contacts of stakeholders involved in one or another way in the hydropower sector were identified in Colombia. Only 9 of them are specifically involved in SHP activities. 3 famous European manufacturers of electrical and electronic equipment are operating in Colombia. Over 60 SHP owners and 10 generator producers are in the country.

The average investment cost of the installed kW is between 900 and 3,000 US$/kW and the cost per kWh produced exceeds 0.05 US$/kWh.

2.4 Hydropower research situation

The fundamental research work on hydropower engineering is not carried out in Colombia, because necessary facilities at universities or research entities are not available. There is an urgent need for practical operation and training in SHP.

Based on the conducted survey 9 R&D projects were identified as carried out by the Universidad Nacional de Colombia, Universidad Católica de Colombia, Universidad Distrital Francisco José de Caldas and Universidad Libre de Colombia between 2011 and 2018. A few projects dealt with micro and mini hydro.

The Colombian Atlas of Hydropower Potential was produced (UPME, 2015). As proponents affirm, this atlas is a tool that guarantees adequate planning for the country's energy supply. A short review of the papers published in peer-reviewed journals revealed that the applied research level for the Colombian hydropower sector is quite satisfactory.

2.5 Prospects

2.5.1 Large hydro

In total, 125 hydropower projects are in the pre-feasibility stage according to UPME. These would add about 5,600 MW to the existing installed capacity. By comparison, over 300 solar and wind projects are also registered, representing 2,775 MW of additional installed capacity (IHA, 2018). Some 212 projects were registered by June 2016, with a total capacity of 7,585 MW, including 128 hydropower projects with a total capacity of 4,227 MW (H&D, 2019).

2.5.2 Small hydro

Despite the untapped large hydropower potential and the developed atlas of hydropower potential in the country, comprehensive data regarding small hydropower potential is not available. There is a Central Register Office for projects planned for construction. As of February 2019, there were thirty more small plants, with a total capacity of 285 MW, having their feasibility studies or designs ready (H&D, 2019).

3 ECUADOR

3.1 Power sector and renewable electricity policy

One decade ago, Ecuador relied on oil and its by-products for energy generation, nowadays the hydropower generation has gained more importance since the Ecuadorian government committed to obtaining a cleaner energy system through the development of renewable energy projects.

The country total effective installed capacity from all sources is 8,662 MW (2018), comprising: hydropower (5,066 MW); thermal plants with fossil fuels (3,395 MW); thermal biomass plants (144.3 MW); thermal biogas (7.3 MW), solar PV (27.6 MW); and wind power installations (21.2 MW).

The Ministry of Energy and Non-Renewable Natural Resources (MERNNR) announced the Government's target to have 80 % of the country's electricity supplied from renewable sources, mainly hydropower.

3.2 Hydropower sector and potential

Ecuador has a gross theoretical hydropower potential of 90,970 MW, equivalent to 638,000 GWh/year (H&D, 2019). The economically feasible installed capacity is 25,550 MW. CONELEC (2012) and IDB (2013) indicate a bit different estimates of theoretical and economically feasible hydropower potential – 77,000 and 21,520 MW, respectively. So far, about 19.7 % of the technically feasible potential has been developed. Ecuador's total hydro capacity was 5,041 MW in August 2019.

The average annual generation from hydropower between 2006 and 2015 was 10,880 GWh, about 45 % of total generation. In 2018, generation from hydro was 20,696 GWh (70.2 %), a notable increase compared with the years mentioned above. There are 31 large hydro plants (>10 MW) in operation, with a total capacity of 4,973 MW.

3.3 SHP situation

SHP definition in Ecuador is up to 10 MW. In practice, installations of slightly higher capacity are classified sometimes as small ones. There are 41 small, mini, or micro-hydro plants (<10 MW) in operation, with a total capacity of about 102 MW.

Ecuador is one of the very few Latin American countries that implemented a feed-in tariff (FIT) scheme for renewable energy (Vargas et al. 2018). For small hydropower of up to 10 MW, the FIT rate is 0.0781 US$/kWh.. Small-scale electricity producers (with a capacity smaller than 1 MW) do not require a permit for operation (Decree 1581 of 1999).

There are at least 11 companies in the country to some degree acting in SHP consultancy, design and construction operation & maintenance. Hydraulic machinery manufacture is not well developed.

3.4 Hydropower research situation

In total, some 29 R&D projects were identified conducted between 2013 to 2019. Twelve of them are dealing with medium or large hydro, only one is a demonstration project.

Almost all the projects were conducted by universities, most frequently by Escuela Politécnica Nacional (EPN). No fundamental research (also known as basic research or pure research) elements have been identified. Although for some applications the state-of-the-art numerical modeling (CFD, 3D Flow) is used. This shows that knowledge level and expertise for designing hydropower plants in the country are quite sufficient.

3.5 Prospects

3.5.1 Large hydro

Currently, the investment in hydropower projects focuses on projects of medium and large capacity, which are supported with foreign credits. For instance, large hydropower plants have been recently financed by the Chinese Exim Bank and built by the Sinohydro Corporation. Community opposition is manifested, particularly regarding private and large hydro projects.

ANDRITZ HYDRO, an EU based global supplier of electromechanical systems, has a long history in Ecuador. Since then this manufacturer delivered and rehabilitated more than 60 units with a total output of about 2,000 MW, representing an impressive 88 % of the nation's hydropower capacity.

At least 100 hydropower project studies were carried out in the country, which resulted in the total power capacity exceeding 4,150 MW. The country expects to meet the national domestic energy demand and export surplus energy to Colombia and Peru.

The Ecuadorian Electrification Master Plan 2018-2027, developed by the MERNNR jointly with other relevant entities envisages 19 hydropower projects totaling 3.6 GW of new capacity by 2027, as well as an additional 550 MW of solar, wind, and other non-conventional renewables.

3.5.2 Small hydro

Dependency on large hydropower makes larger projects a priority for the Government and limits the interest in SHP investment. Some 40 SHP projects with a total capacity of 225 MW already completed the final design stages and are ready to go ahead for construction.

Last summer in 2019, Ecuador's government started launching auctions for renewable energy projects, including small hydro installations, through which it intended to allocate around 500 MW of power generation capacity. Developers will be granted a 25-year PPA, while the sole off-taker of the generated energy will be state-owned utility Corporacion Electrica de Ecuador, S.A.

4 CAMEROON

4.1 Power sector and renewable electricity policy

The total installed capacity of all powerplants (as of 2017) is 1,529 MW, of which 816 MW is hydro. Total production in 2017 was 6,973 GWh, of which 5,090 GWh was contributed by hydro (73 %) (H&D, 2019). About 26 % of national electricity production is based on the use of imported fuels.

A development plan for the electricity sector was established in 2006 and updated in 2014 to meet the 2035 energy target. Cameroon also intends to increase the share of renewable energy in the energy mix from 1 % to 25 % by 2035.

Despite the well-established power sector framework, there is still a lack of adequate regulation and institutional setting for the off-grid and on-grid, renewable energy and energy efficiency sectors.

4.2 Hydropower sector and potential

The country has the fourth-largest hydropower potential in Africa behind the Democratic Republic of Congo, Madagascar, and Ethiopia (Kenfack and Hamandjoda, 2012). The gross theoretical hydro potential of Cameroon is 294 TWh/year. Of this, 115 TWh/year is considered technically feasible, and 105 TWh/year economically feasible. Only about 4 % of the technically feasible capacity has been developed. There was 816 MW of hydro capacity in operation (in 2017). The total installed capacity of all power plants (as of 2017) is 1529 MW, of which 816 MW is hydro. Total production in 2017 was 6,973 GWh (latest available data), of which 5,090 GWh (73 %) was contributed by hydro (H&D, 2019).

As of 2019, only 8 hydropower plants are operational or under construction, out of which three are small schemes in the country.

4.3 SHP situation

The upper capacity limit of SHP in Cameroon is 10 MW. The complete assessment of small hydropower potential is yet to be done. The country is still looking for funds to make an in-depth assessment of the small hydro potential. A very preliminary list of locations of sites for potential micro to small hydropower plants is freely accessible (ONUDI, 2019).

Mini-grids, powered by pico- and micro- hydropower plants, are a relatively new rural electrification strategy in Cameroon. Several of such mini-grids have been developed in the mountain regions of the country (Ministry of Energy, 2018). As of 2017, the installed capacity of SHP was at least 1 MW, however, comprehensive and accurate data on total installed capacity are not currently available.

The small hydropower potential is estimated to be at 970 MW (WSHPDR, 2019). Other sources provide SHP power generation potential estimated at 1.115 TWh, concentrated mainly in the Western and Eastern regions (Nematchoua et al. 2015).

Only a few companies are involved in the small hydropower sector (EdF, IED-Invest, Synohydro). The hydropower equipment manufacturing industry does not exist at all. But this situation is going to change very soon.

The average investment cost for small (low head <20 m) and medium to large hydro (>50 MW) schemes are 2,689 and 3,482 (€/kW), respectively. The average cost per kWh of electricity produced is 8.3 and 6 euro cents, respectively. No feed-in tariff system to support renewable electricity deployment has been introduced.

Although the hydropower sector is still not well developed in Cameroon, a large number of stakeholders (some 60) are involved in one or another way in the sector. Seven of these stakeholders represent EU companies (including the UK), 12 - China, and 1 - the USA.

4.4 Hydropower research situation

Only one R&D project conducted by the University of Yaoundé has been reported related to the establishment of a small hydro laboratory. A couple of applied projects dealing with micro-hydropower plants were completed at the National Advanced School of Engineering, University of Yaoundé (Kengne Signe et al, 2017, 2019).
At least a dozen papers directly or indirectly related to hydropower issues were published during the last 8 years in the scientific journals of Renewable Energy, Renewable and Sustainable Energy Reviews, Energy Procedia, Energy Policy, Environmental Science & Policy.

4.5 Prospects

4.5.1 Large hydro

Substantial hydropower potential presents many investment opportunities for the future. Given this large hydro potential, the development of hydro plants could make the country a net electricity exporter in the future. Four neighbouring countries, Chad, Nigeria, Gabon, and Equatorial Guinea, have already expressed interest, and there are plans to build transmission lines between the four countries as soon as more hydro plants are developed (H&D, 2019).
However, the negative effect of climate change should be underlined. So far persistent power outages used to take place throughout the country, especially in the dry seasons when water levels in reservoirs are low (Muh et al., 2018).
Large hydro plants planning or construction is taking place in the country. E. g., the 420 MW Nachtigal scheme, the 398 MW Songdong scheme, the 600 MW Chollet scheme. A private developer is planning to implement the 485 MW Kpep scheme which could eventually have a total capacity of 850 MW, another one to construct the Makay complex (400 MW).

4.5.2 Small hydro

About 20 small schemes have been identified for the next 10 years. There are some plants (20 kW to 3 MW) abandoned due to grid extension and political instability. A very preliminary list of locations of sites for potential micro to small hydro plants is freely accessible (ONUDI).

The Cameroonian government is struggling to cope with a low electricity access rate in the country. The lack of private investment is the root cause of the low electricity access rates in rural areas in Cameroon. Therefore, it has drafted policies favouring the participation of private investors in the sector that started working. Tens of memorandums of understanding (MoU) from a few MW to hundreds of MW in hydro capacity are being concluded. The companies are coming from almost all over the world.

5 UGANDA

5.1 Power sector and renewable electricity policy

Only about 50 % of the population has access to electricity, and in rural areas access at least 3 times less. Uganda has one of the lowest levels of per capita electricity consumption in the world with 215 kWh per capita per year. In 2017, electricity generation in Uganda totaled 3,874 GWh with a clear dominance of hydropower share.

The current contribution of hydropower in Uganda's electricity generation mix is 87 %. This figure will go up to 92 % once large Karuma HPP is commissioned. Hydropower is a key component in the electricity generation expansion plan in line with the Uganda Vision 2040 strategy (NPA, 2007; IHA,2019).

The Renewable Energy Policy, initiated by the Government of Uganda in 2007 (GoU, 2007) stated the goal to increase the use of modern renewable energy as well as the introduction of FiT remuneration mechanism and standardization of PPA. This has encouraged both individual investors and companies to invest in the generation of RE in Uganda.

5.2 Hydropower sector and potential

The gross theoretical hydropower potential of the country has not been fully assessed (H&D, 2019). The technically feasible potential of Uganda is 20,833 GWh/year and the economically feasible one - 12,500 GWh/year. About 15 % of the technically feasible potential has been developed so far. In 2018, hydro plants generated 3,638 GWh, which was 89 % of the total generation. Generally, the contribution of hydro each year is more than 80 %. As of 2019, Uganda had 32 hydropower plants that were in operation, with a total installed capacity of 1,667 MW. This inventory comprises some 20 micro and small hydropower plants (up to 10 MW).

5.3 SHP situation

In Uganda, SHP is generally defined as hydropower plants with an installed capacity of up to 20 MW (ERA). These sites are located mainly in the Western and the Eastern regions of the country which are hilly and mountainous. About 50 potential small hydropower sites have been identified at the Ugandan rivers. So far SHP potential has not been fully assessed in the country, only rough estimates can be provided (some 1,250 GWh/year).

Small schemes are generally privately owned and operated by the IPPs. To date, there is 20 SHP under operation, but access to their data is restricted. Currently, on average the investment costs are approx. US$3 to 4 million per MW installed.

Some 40 stakeholders are acting in the hydropower sector, mostly in small-scale hydro. No hydraulic machinery equipment producers were identified (only a few dealers) so far.

The REFiT applies to systems of prescribed priority technologies (SHP and other renewables) of installed capacity in the range of 0.5 to 20 MW, as defined by the Electricity Act, 1999. In addition, to qualify for the REFIT, the projects must be connected to the national grid. Feed-in Tariff for micro hydro (<1MW), mini (<9MW), and small hydro (<20MW) vary from 0.115 to 0.085 US$/kWh with a repayment period of 20 years.

5.4 Hydropower research situation

Renewable energy programs proposed by universities are not offering in-depth or sufficient knowledge of hydropower issues. This suggests that the research level in hydropower is quite weak. On the contrary, only the main features and challenges of hydropower plants projects under development or already under operation, including a few of them of demonstration type are provided.

During the last eight years at least 5 papers related to one or another way with hydropower, topics were published and affiliated to Makerere, Mbarara, and Kampala International Universities, and the Centre for Research in Energy and Energy Conservation (CREEC). All the above outlined conclude that the research related to the hydropower sector possesses minor potential.

Since hydropower development is starting to progress in this country the basic hydropower knowledge would be advantageous. There is a need to transfer European-top-level experience, knowledge, available state-of-the-art hydro technology to Ugandan researchers.

5.5 Prospects

Uganda Vision 2040 identifies electricity generation as one of the key strategic interventions for the social-economic transformation of the country. This includes increasing access to 30 % in 2020 and 80 % in 2040 (a 6 % annual increase), with off-grid electricity playing only a minor role. While this is expected to be mainly low-carbon due to large hydropower resources, there is a potential to achieve 100 % access cost-effectively by 2040 with a greater emphasis on small-scale off-grid renewable solutions (IHA, 2019). There should be also pointed out, that hydropower is sensitive to the climate-driven hydrological cycle thus necessitating proper management of the river catchment areas.

The key challenges for hydropower development in Uganda, and most countries in Africa, include the need for substantial up-front investment capital which cannot easily be raised by the sector, as well as environmental and social concerns such as the resettlement and compensations of persons affected mainly by the large hydro projects, and inadequate local implementation experience and technical capacity.

5.5.1 Large hydro

To ensure the development of hydropower resources sustainably, in 2010 the government undertook a hydropower development master plan study (JICA, 2011). The study targeted sites above 50 MW mainly along the River Nile. In line with this hydropower master plan, the government is fast-tracking the development of the identified hydropower sites. It is currently implementing two key flagship hydropower projects namely, Isimba (183.2 MW) and Karuma (600 MW). Other large hydropower plants being packaged for development include Ayago (840 MW), Orianga (392 MW), Uhuru (350 MW), and Kiba (290 MW). (IHA, 2019).

To address the challenge of financing, the Government of Uganda put in place the Energy Investment Fund which enabled to commencement of the construction of the Bujagali hydropower plant. The 250 MW Bujagali hydropower plant was developed under a public-private partnership arrangement with Bujagali Energy Limited (BEL). Additional investment capital has been attracted through bilateral financing with our development partners. The challenge of inadequate technical capacity has been addressed by putting in place a local content policy to ensure the participation of Ugandans during the construction of the projects.

5.5.2 Small hydro

A total of 59 mini-hydropower sites with a potential of about 210 MW have been identified through different studies. Some of the sites can be developed for isolated grids and others as energy supply to the grid (Fashina 2019).

Regarding small hydropower projects, the current policy is that their development is undertaken by the private sector. The Renewable Energy Feed-in Tariffs (REFiT) are in place to promote investment in small hydropower and other renewable power projects (IHA, 2019).

There are many unexploited potential SHP sites in Uganda, which could potentially supply electricity to areas not covered by the national grid. Their data are available at ERA and some of these sites are listed in WSHDR (2019).

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